

Characterization of Zooplankton Community and Size Composition in Relation to Hydrography and Circulation in the Sea of Japan

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LONG-TERM GOAL

My ultimate scientific goal is to understand both the biological (e.g., population structure and dynamics and behavior) and physical (e.g., advection, mesoscale physical processes, turbulence) mechanisms that act in concert to produce the observed distributions of plankton in the ocean. My approach has been to conduct a combination of field observations and experiments to measure vital rates (grazing, egg production). Observational studies define the temporal changes in the distributional patterns of population structure resulting from population growth, swimming behavior, and physical transport. Experimental work describes vital rates and how these rates may be impacted by the environment to determine the ultimate success of the population.

OBJECTIVES

- 1) To characterize the zooplankton community of the Japan Sea in terms of taxonomic composition and size structure.
- 2) To determine the relationship between zooplankton taxa and their associated environmental variables over scales from centimeters to hundreds of kilometers. This information will provide insights into the origins of the different zooplankton taxa.
- 3) To consider the potential flux or exchange of zooplankton into and out of the Sea of Japan through the straits, so that the contribution of physical exchange to resident populations can be quantified.
- 4) To describe the distribution of acoustic scatterers across and along the subpolar front and other hydrographic features, to depths of 200-300 m, through analysis of acoustic backscatter intensity estimated using the acoustic Doppler current profiler that operated during the cruises to the JES.

APPROACH

These objectives require the ability to obtain high resolution temporally and spatially coincident measurements of both biological and physical characteristics, which then permits description of the coupling between biological and physical distributions and of the distributions of zooplankton and associated variables over scales from centimeters to hundreds of kilometers. To achieve this, a combination of new technology (the Video Plankton Recorder) coupled with more standard techniques

(shipboard acoustic Doppler current profiler, net sampling) was utilized. High resolution measurements of the basin-scale distributions of zooplankton abundance and taxonomic and size composition in relation to the hydrography, currents, light, fluorescence, and beam attenuation in the upper water column (80 m) were obtained using the Video Plankton Recorder (VPR) in the southern Japan Sea during June-July 1999 from the *R/V Roger Revelle*. The VPR is essentially an underwater microscope that images plankton at two different magnifications. The instrument is mounted on a V-fin that is towed behind the ship, undulating between the surface and a selected depth. Video images and associated hydrographic and biological data are transmitted from the towed vehicle to the ship via fiber optic cable. In-focus images of plankton are extracted from the video and identified to taxa in real time. Plankton abundances and hydrography are plotted in real time. Acoustic Doppler current profiler (ADCP) backscatter intensity data were collected using the hull-mounted ADCP on the *Revelle* during June-July 1999 and also on several other cruises conducted at different periods of the year (spring, winter). I collaborated substantially with Dr. Lynne Talley (SIO), who was chief scientist on the cruise and conducted basin-wide CTD measurements as part of the ONR Japan/East Sea DRI. I collaborated also with Dr. Steven Ramp, who is examining the dynamics of the Ulleung Basin and East Korean Warm Current/North Korean Cold Current confluence using hydrographic data collected with the VPR, to describe the biological-physical associations in this region. I also collaborated with Dr. Charles Flagg (BNL) who processed the ADCP data, to describe the spatial distribution of backscatter intensity (a proxy for plankton or nekton abundance) across the Japan/East Sea. The work will provide a better understanding of how boreal and tropical zooplankton communities maintain themselves in a dynamic physical environment.

WORK COMPLETED

The taxonomic and size composition of the zooplankton community in the upper 80 m of the Japan/East Sea was described and mapped in real time using the Video Plankton Recorder during June 17 - July 23, 1999 on Dr. Lynne Talley's cruise on the *R/V Roger Revelle*, surveying over both the northern and southern regions, the Subpolar Front between, and the Ulleung Basin. The instrument sampled between near surface and 80 m for much of the survey with an inter-profile distance of ~7 kilometers and an along-path resolution of centimeters. A total distance of 3562 kilometers was sampled and over 240 hours of video and associated data were collected and processed. Pressure, temperature, conductivity, fluorescence, light transmission, ambient light, P-Code GPS position and time (UTC) and Knudsen Echo Sounder depth data also were logged. Acoustic Doppler current profiler data were collected; velocity data have been entered into a database at Brookhaven National Laboratory under the supervision of Dr. Charles Flagg. During the cruise, hydrographic and taxon specific plankton distribution data were displayed in real time. In addition to the primary sampling with the VPR, fifteen plankton tows were conducted using a 1-m² (mouth area), 150 µm mesh ring net towed obliquely between the surface and 80 m.

Identification of all images from both the high and low magnification camera is completed. Over 90% of the video images collected with the high magnification camera were analyzed at sea; the remaining 10% were analyzed shortly after the cruise. Eight taxa were identified from the low magnification camera; calanoid copepods, *Oithona* (a cyclopoid copepod), copepod nauplii, diatom chains, acantharia, sarcodina, larvaceans, and large protozoa. Identification of the video images from the low magnification camera was completed post-cruise. Only two plankton types were observed/identified with the low magnification camera: unidentified copepods and copepods of the genus *Calanus*. Silhouette analyses of the plankton samples from the ring net tows (taxa specific sizes and abundances) are completed.

The plankton data were merged with hydrographic and velocity data in addressing how the physical environment (fronts, advection, water mass type) influences the plankton communities of this marginal sea to elucidate the biological/physical interactions controlling zooplankton abundance and community structure in a semi-enclosed marginal sea and will allow us to better understand how zooplankton communities maintain themselves in a dynamic physical environment. Two papers have been completed based on the VPR work: one describing the hydrography of the Ulleung Basin and a second describing characteristics of the zooplankton community of the JES Basin in association with hydrography using data from both VPR cameras and the net tows. Results from both analyses were presented at the 2002 Ocean Sciences Meeting. Processing of the acoustic backscatter intensity from the ADCP has been completed. Work during the next year will concentrate on analyzing the spatial and temporal trends in acoustic backscatter intensity.

RESULTS TO DATE

1. The cruise track surveyed two (three) hydrographic regions which had distinct temperature-salinity properties: the southern Japan Sea (south of the SPF), the northern Japan Sea north of the SPF), and the region off of Hokkaido Island, Japan. Considerable mesoscale complexity in hydrography and circulation was observed.
2. "Copepods" was the most numerous taxon found with all instruments.
3. The taxonomic composition (e.g., % copepods) of the plankton varied according to hydrographic region.
4. Plankton abundances varied with hydrographic region, although strong associations were not always observed.
5. The size composition of the plankton varied according to hydrographic region and the size categories of plankton targeted by the each instrument.
6. The vertical distributions of copepods and fluorescence were associated with hydrographic structure. Depth distribution of biological variables changed with changing water column vertical structure, especially at fronts.
7. Because of the dynamic environment, differences in plankton size and taxonomic composition were less dramatic than had been hypothesized.

IMPACT/APPLICATION

The proposed study has shed light on the biological/physical interactions controlling zooplankton abundance and community structure in a semi-enclosed marginal sea. The mixture of the two communities and the potential establishment of a transitional community along the Subpolar Front demonstrated how the affinities of zooplankton communities change in response to advective transport and how mesoscale features promoted exchange between different planktonic and hydrographic regimes. Such information allows us to better understand whether zooplankton communities can maintain themselves in a dynamic physical environment.

TRANSITIONS

Our findings will allow better predictions of how zooplankton and large phytoplankton abundance patterns change as a function of hydrography and currents in the Japan Sea. More generally, the findings will provide a better understanding of how plankton and physical properties are distributed in relation to each other over a broad range of scales in the vicinity of a sharp biogeographic frontal region. This information then can be used to better understand variability in sound and light scattering properties of the ocean.

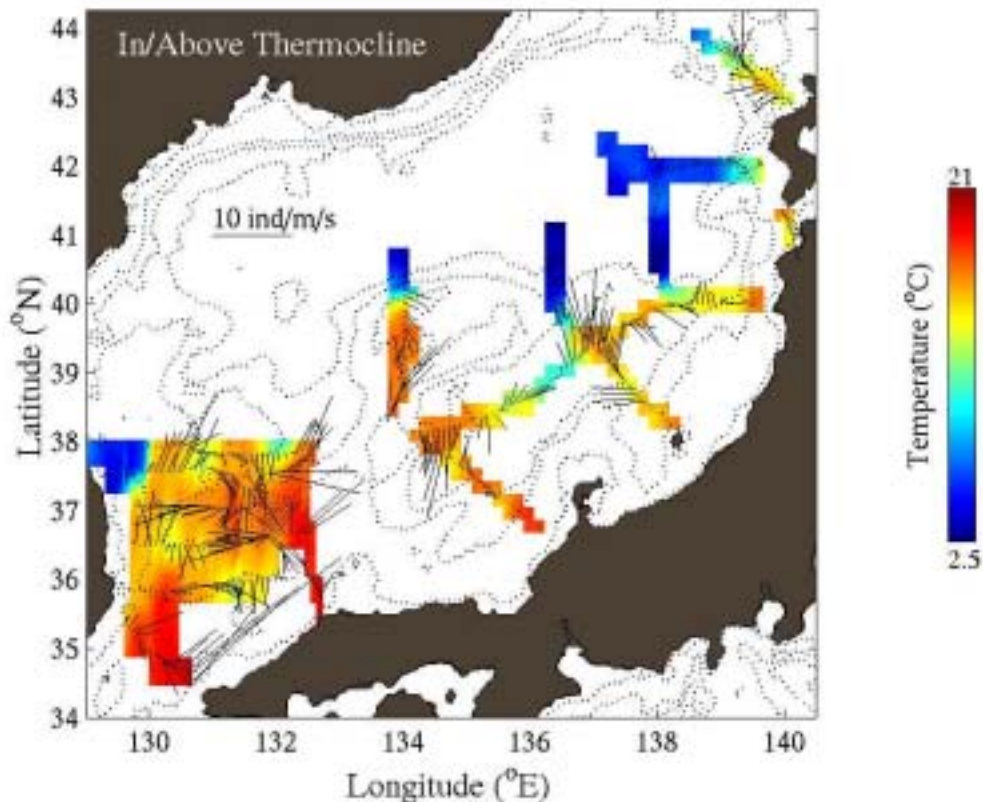


Figure 1: Flux of copepods (vectors) in the upper water column overlain over temperature at 40 m (color scale). Instantaneous flux estimates (individuals/m/sec) were calculated by combining concentrations of copepods measured using the high magnification camera of the VPR with coincident velocity measurements from the hull-mounted acoustic Doppler current profiler. Greatest fluxes were observed in the warmer water types to the south of the subpolar front (seen in the sharp discontinuity in temperature) in the southern Japan/East Sea (note short vectors in cold (blue) water). Note the considerable mixing between water types, as represented by water temperature, associated with the meandering of the current across the Japan/East Sea (seen in the sharp discontinuity between temperature) [The plots show maps of the temperature as color shading over the surveyed region relative to topographic features with vectors overlain showing the magnitude and direction of the instantaneous flux of copepods.]

RELATED PROJECTS

This work will be integrated with the Japan Sea DRI which involves many investigators in physical and optical oceanography., including S. Ramp (Ulleung Basin and NKCC/EKWC confluence).

PUBLICATIONS

Ashjian, C.J., Davis, C.S., Alatalo, P. Characterization of the zooplankton community, size composition, and distribution in relation to hydrography in the Japan/East Sea. Submitted to Deep-Sea Research II.

Ramp, S.R., F. L Bahr, C. J. Ashjian, and L. D. Talley. The upper-ocean circulation in the Ulleung Basin during June-July 1999. Submitted to Deep-Sea Research II.